



# ExoPlanet Exploration Program

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Program Manager

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ExoPAG - 7



# Exoplanet Exploration Program

- Science
- Technology
- Kepler Mission
- NASA Exoplanet Science Institute
  - Kepler archives and tools
  - Sagan Fellowship
  - Keck single aperture
- WFIRST Mission
  - AFTA STDT
  - Study Office
- Large Binocular Telescope Interferometer
- Technology Development Program
- Public Education and Engagement
  - Eyes on Exoplanets
- Opportunities: Exoplanet Observatory
- Exoplanet STDTs

# ExO: The Exoplanet Observatory Astrophysics

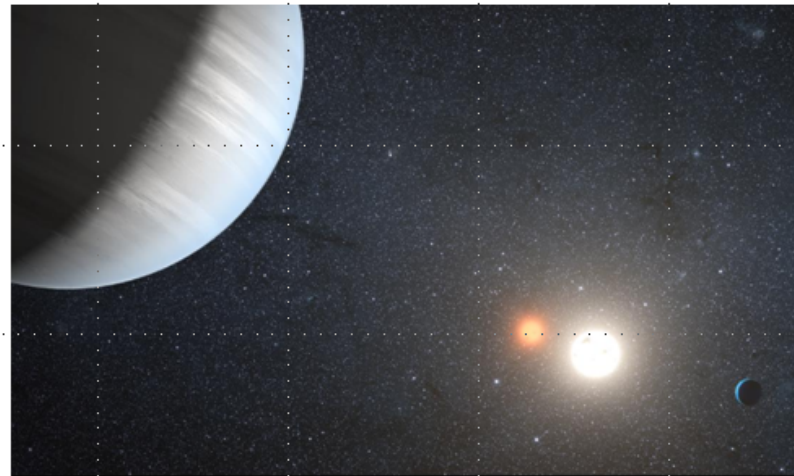
## Overview

**POC:** Gary Blackwood, Exoplanet Exploration Program  
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**Key collaborators:** Exoplanet Exploration Program Office and list of supporting individuals.

**Goals:** The prime objective of the *Exoplanet Observatory* will be to provide a detailed portrait of exoplanets around our nearest F, G, K, and M stars. *ExO* will operate at visible and near-infrared wavelengths to directly image gas/ice giants down to the largest of terrestrial planets. *ExO* will measure their spectra and determine their orbits. It will image debris disks and characterize exozodiacal dust. *ExO* complements this data through astrometry to measure exoplanet masses and orbits, and through spectroscopy to study large transiting planets close to their stars.

*ExO*'s General Observer Program will provide new opportunities for NASA Cosmic Origins science and Planetary Science.



## Description

### Instruments:

- High-contrast coronagraph with Integral Field Spectrograph, imaging over 0.4-1.0  $\mu\text{m}$ , at 10% bandwidths, with working angles of 3-60  $\lambda/D$ ,  $10^{-9}$  contrast (baseline) and  $10^{-10}$  (goal) post-processed, with 8x8 arcsec FOV, spatial resolution 0.05 arcsec; and  $R = 70$
- Astrometric Imaging Camera with 3 x 3 arcmin FOV
- Time-resolved Spectrometer observing 0.8-2.4  $\mu\text{m}$ ,  $R=1000$

**Operations:** From a Sun-Earth L-2 orbit, the observatory will sequentially observe accessible nearest-neighbor F, G, K, and selected M stars once per quarter, with direct imaging and astrometry. Transit spectroscopy will be used for appropriate targets.

### Opportunities:

- Instrumented to be fully compatible with a starshade, co-launched or launched separately
- Leverages and complements ground-based radial-velocity observations
- Excellent potential for 50% GO science and international collaboration

**Human exploration:** The observatory will be designed for robotic servicing

## Value to NASA

### Advances the Priorities of NASA's Astrophysics Division

- *ExO* addresses New Worlds, New Horizons 2010 #1 medium-scale recommendation for a New Worlds Technology Development Program to address "*preparation for a planet-imaging mission beyond 2020, including precursor science activities*" (p. ES-6).
- *ExO* addresses NWNH 2010 small-scale recommendation "*understanding the birth of galaxies, stars, and planets*" (p. ES-4).


### Advances Technology highlighted by NASA's Space Technology Mission Directorate

- Advances high-contrast imaging and spectroscopy technology
- Prepares NASA for a later mission to image Earths and search for signs of life.

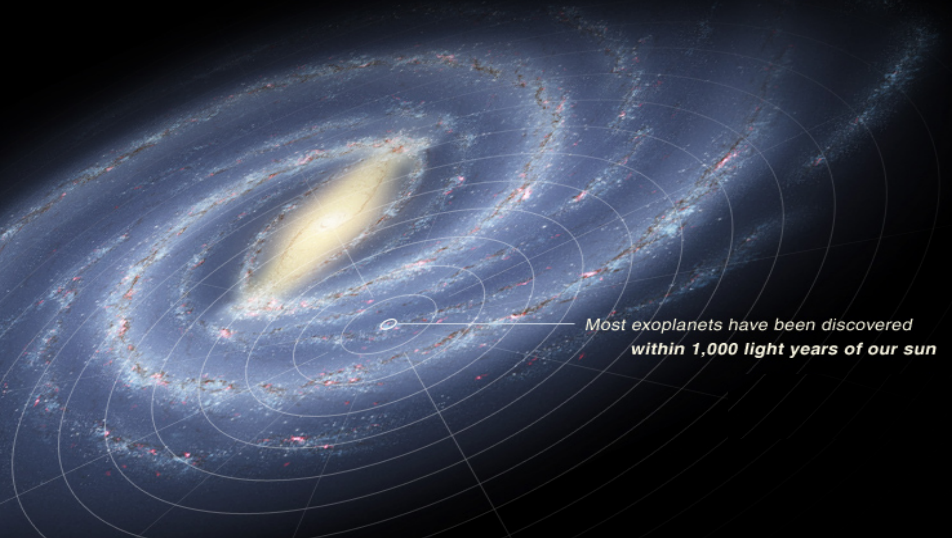
**Provides Education and Public Outreach opportunities tied to the exploration for life in our galactic neighborhood.**



# Eyes on Exoplanets 3D Visualization



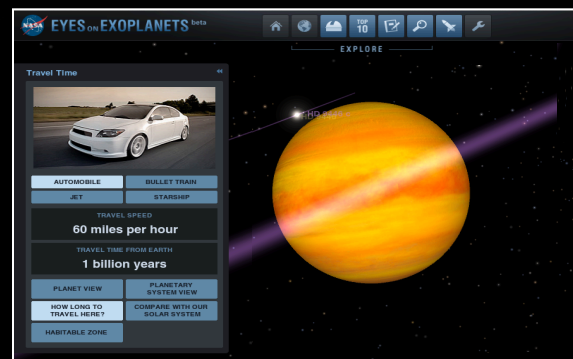
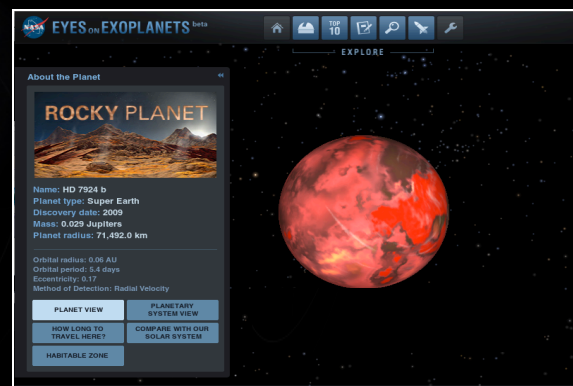
## EYES ON EXOPLANETS beta



Most exoplanets have been discovered  
within 1,000 light years of our sun

- 3D visualization of all confirmed exoplanets
- Distance scales, habitable zone overlays, and tools for comparisons
- Searchable and continuously updated


<http://eyes.nasa.gov/exoplanets>  
Powered by NASA's Exoplanet Archive database





# Highlights and Latest Discoveries

 **EYES ON EXOPLANETS** beta





### Highlights



2012-07-21  
Astronomers discover planetary odd couple



2012-06-12  
Faraway fireworks



Five potential 'Earths' around one star



Introducing the first 'Super Jupiter'

### Latest Discoveries

Nov 19, 2012 - Kappa And b

Nov 07, 2012 - HD 40307 f

Nov 07, 2012 - HD 40307 g

Oct 17, 2012 - Alpha Cen B b






PLANET COUNT **817**

STARS WITH PLANETS **642**








EARTHLIKE PLANETS **0**






# Planet View

 **EYES ON EXOPLANETS** beta



EXPLORE

### About the Planet



**Gas Giant**

**Name:** epsilon Eri b  
**Planet type:** Gas Giant  
**Discovery date:** 2000  
**Mass:** Unknown  
**Planet radius:** 71,492.0 km

**Orbital radius:** 3.39 AU  
**Orbital period:** 2502.0 days  
**Eccentricity:** 0.702  
**Method of Detection:** Radial Velocity

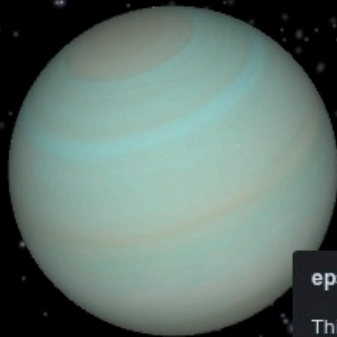
PLANET VIEW

PLANETARY SYSTEM VIEW

HOW LONG TO TRAVEL HERE?

COMPARE WITH OUR SOLAR SYSTEM

HABITABLE ZONE






### epsilon Eri b

This planet is a gas giant, similar to Jupiter, Saturn or Neptune in our solar system. Since gas weighs much less than rock, and since gravity is the reason planets form, gas giant planets are much larger than rocky planets like Earth. They lack a solid, well-defined surface and are considered unpromising targets in the search for life.

» click anywhere to close.


SPEED 









Paused

REAL RATE   




# Compare to our Solar System

 **EYES ON EXOPLANETS** beta



**EXPLORE**

### About the Star



**Name:** HD 125612  
**Distance from Earth:** 1.630 quadrillion km  
**Visible to the naked eye:** no  
**Constellation:** N/A  
**Planets:** 3

**Star type:** G  
**Magnitude (brightness):** 8.317  
**Mass:** Unknown

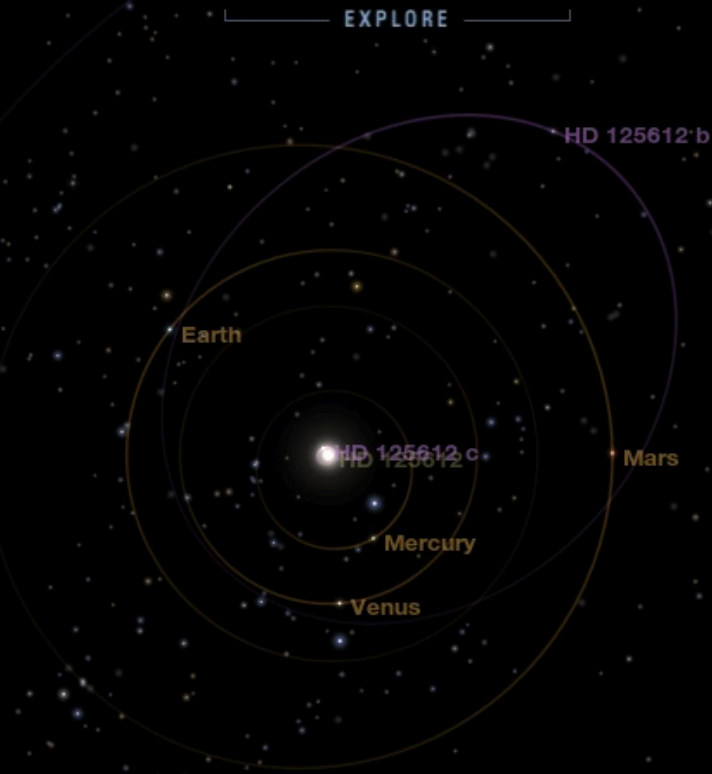
PLANETARY  
SYSTEM VIEW

STAR VIEW

HOW LONG TO  
TRAVEL HERE?

COMPARE WITH OUR  
SOLAR SYSTEM

HABITABLE ZONE



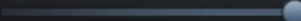



HD 125612 c

Mercury

Venus

Mars

HD 125612 b

**SPEED**  **Paused** **REAL RATE**   



# View from Earth (with Constellations)

The screenshot displays the NASA Eyes on Exoplanets interface. The main view is a star map with constellations outlined in blue. Various exoplanets and stars are labeled, including WASP-8, HD 213240, GJ 832, and Voyager 2. Constellations like Capricornus, Microscopium, Piscis Austrinus, Corona Australis, and Telescopium are visible. A 'View From Earth' panel on the left shows the current location (Latitude: 37.01° N, Longitude: 120.76° W) and options to show all stars or only those visible to the naked eye. A top navigation bar includes icons for home, globe, telescope, top 10, explore, search, and settings. A bottom status bar shows the planet count (817), stars with planets (642), and earthlike planets (0).

**View From Earth**

Latitude: 37.01° N  
Longitude: 120.76° W

☒ Show All Stars  
☐ Stars Visible to the Naked Eye

HIDE CONSTELLATIONS | CHOOSE ANOTHER LOCATION

PLANET COUNT **817** STARS WITH PLANETS **642** EARTHLIKE PLANETS **0**



# Science and Technology Definition Teams

- Ref: Dear Colleague Letter January 4, and draft Charter
  - See <http://exep.jpl.nasa.gov>
- Two direct-imaging probe-scale mission STDTs:
  - ExoD-C: Use of internal coronagraph
  - ExoD-S: Use of external occulter (starshade)
- Respond to Decadal Science and Budget Profile
- Single DRM from each (with CATE) due March 2015
- Schedule:
  - Kickoff May 2013
  - Interim Architecture Trade Study (on or before) November 2013
  - Preliminary DRM September 2014 based on leading option in each STDT
- Supported by ExEP Study Office
- Decision on possible 3<sup>rd</sup> STDT by June 2013